US 20200174773A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0174773 A1**

**Borlick et al.** (43) **Pub. Date: Jun. 4, 2020**

(54) **INTELLIGENT AUTOMATED REMOTE CODE LOAD**

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(21) Appl. No.: **16/209,962**

(22) Filed: **Dec. 4, 2018**

**Publication Classification**

(51) **Int. Cl.**

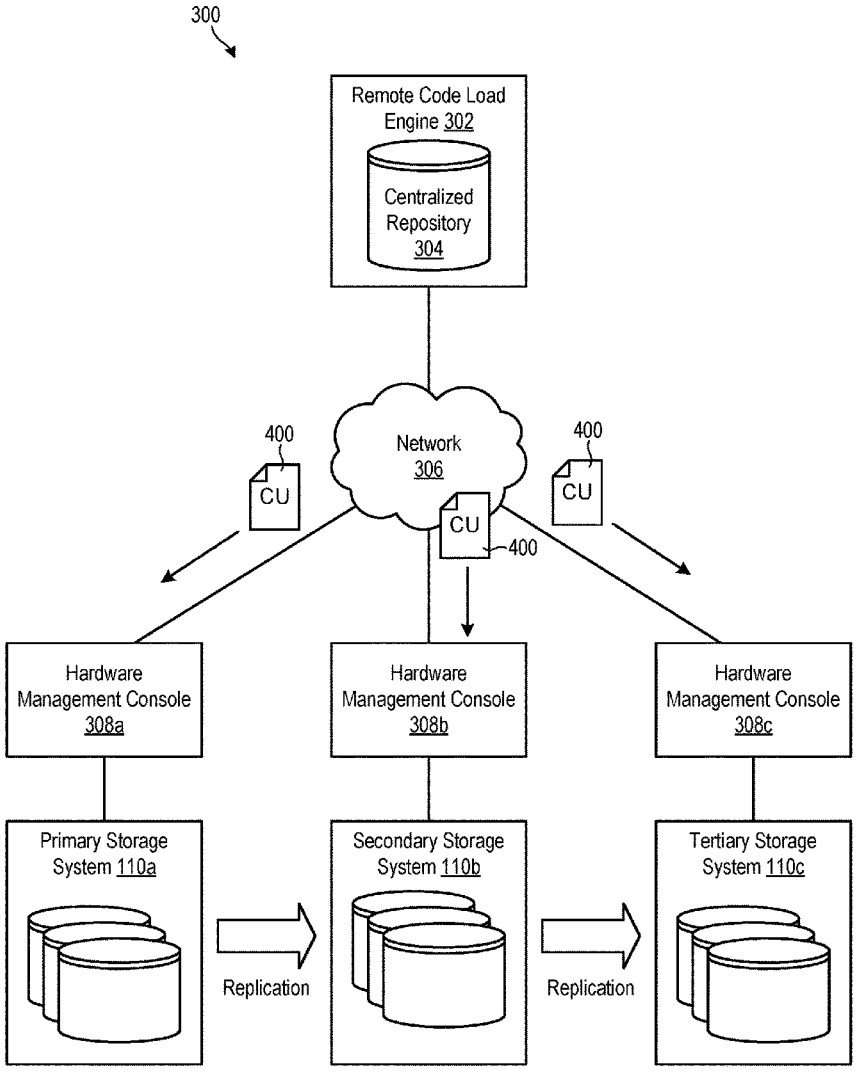
| | |
|---|---|
| ***G06F 8/65*** | (2006.01) |
| ***H04L 29/08*** | (2006.01) |
| ***G06F 11/34*** | (2006.01) |

(52) **U.S. Cl.**

CPC ..... ***G06F 8/65*** (2013.01); ***G06F 11/34*** (2013.01); ***H04L 67/34*** (2013.01)

(57) **ABSTRACT**

A method for updating code in a set of machines is disclosed. In one embodiment, such a method includes receiving a time range within which a code update is to be performed on a set of machines, block out times indicating when the code update cannot be performed, and an order in which the code update is to be performed on the set of machines. For some time period before the code update is performed, the method gathers I/O statistics associated with the set of machines. The method then performs the code update on the set of machines during a period of reduced I/O as determined from the I/O statistics, while complying with the received time range, block out times, and order. A corresponding system and computer program product are also disclosed.



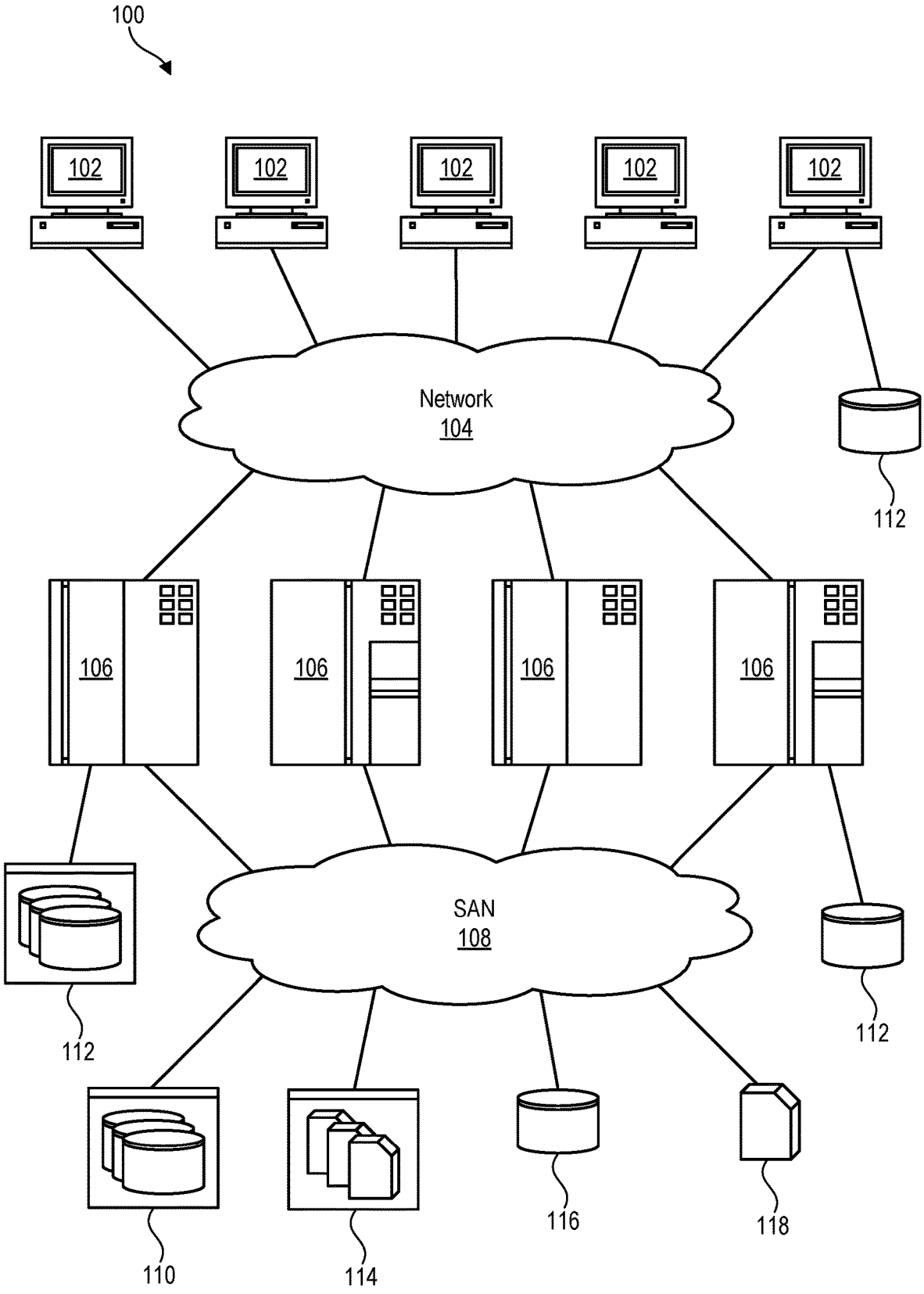

100
102
102
102
102
102
Network
104
112
106
106
106
106
SAN
108
112
112
110
114
116
118

Fig. 1

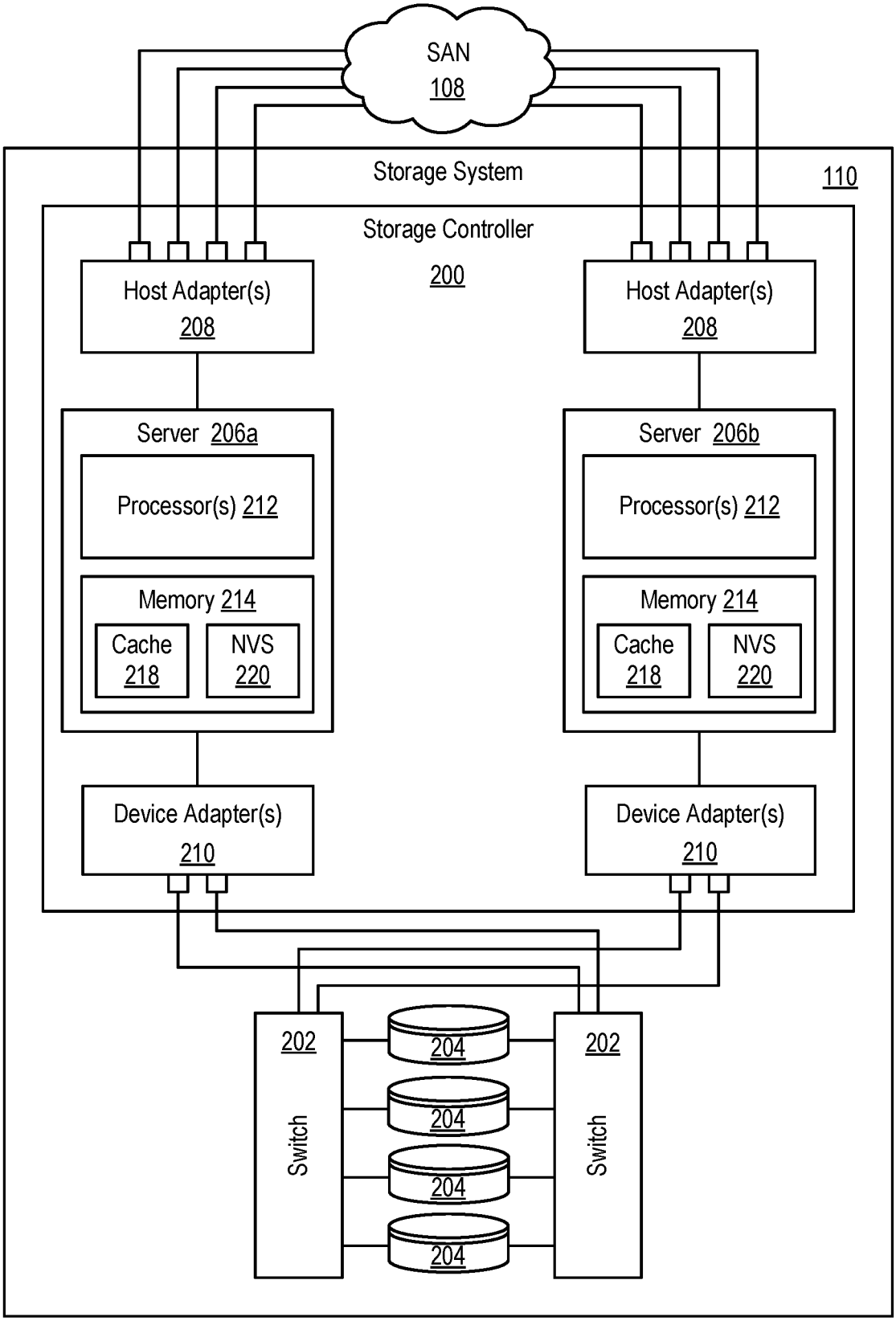

SAN
108
Storage System
110
Storage Controller
200
Host Adapter(s)
208
Host Adapter(s)
208
Server 206a
Processor(s) 212
Memory 214
Cache
218
NVS
220
Server 206b
Processor(s) 212
Memory 214
Cache
218
NVS
220
Device Adapter(s)
210
Device Adapter(s)
210
202
Switch
204
204
204
204
202
Switch

Fig. 2

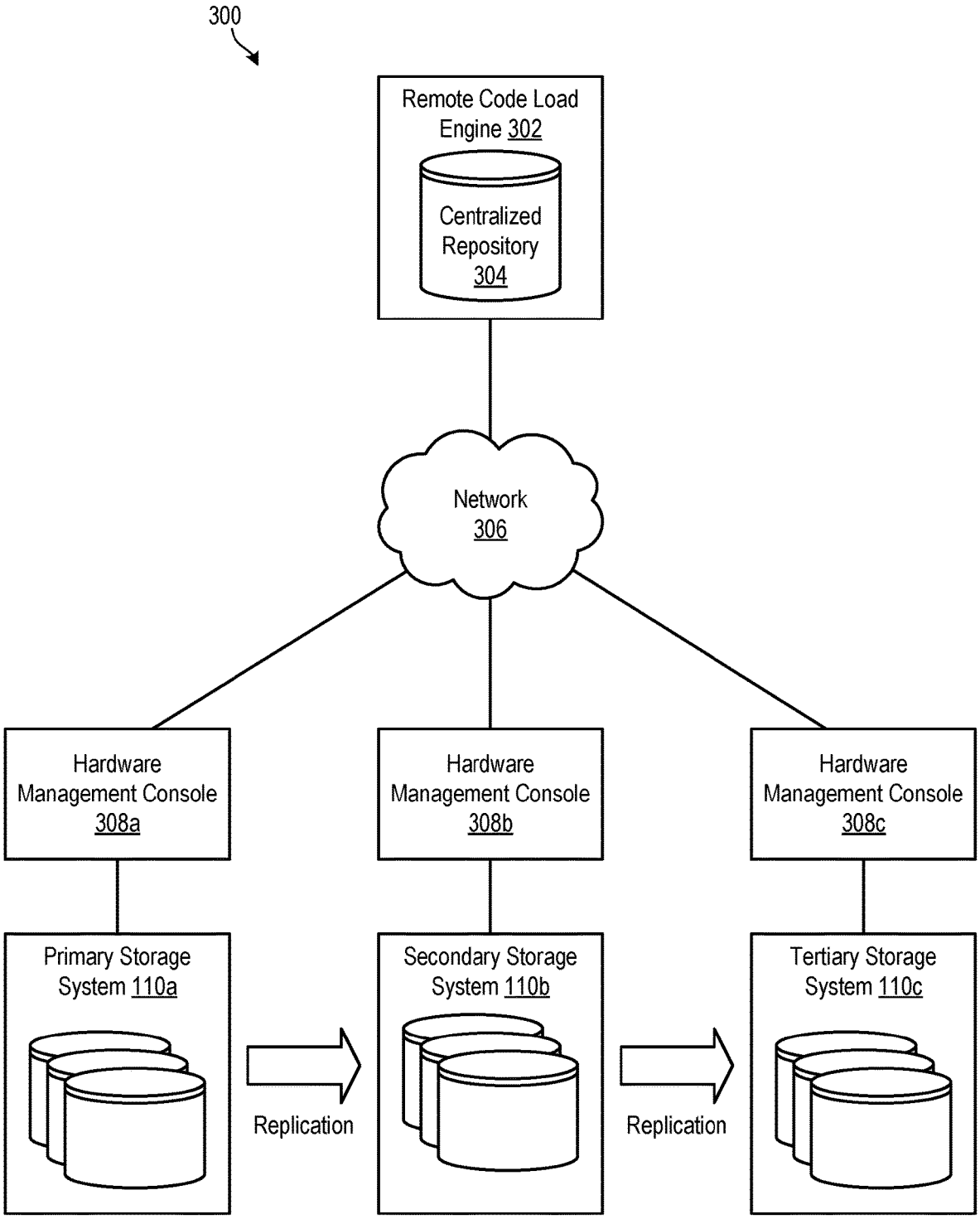

300
Remote Code Load Engine 302
Centralized Repository 304
Network 306
Hardware Management Console 308a
Hardware Management Console 308b
Hardware Management Console 308c
Primary Storage System 110a
Secondary Storage System 110b
Tertiary Storage System 110c
Replication
Replication

Fig. 3

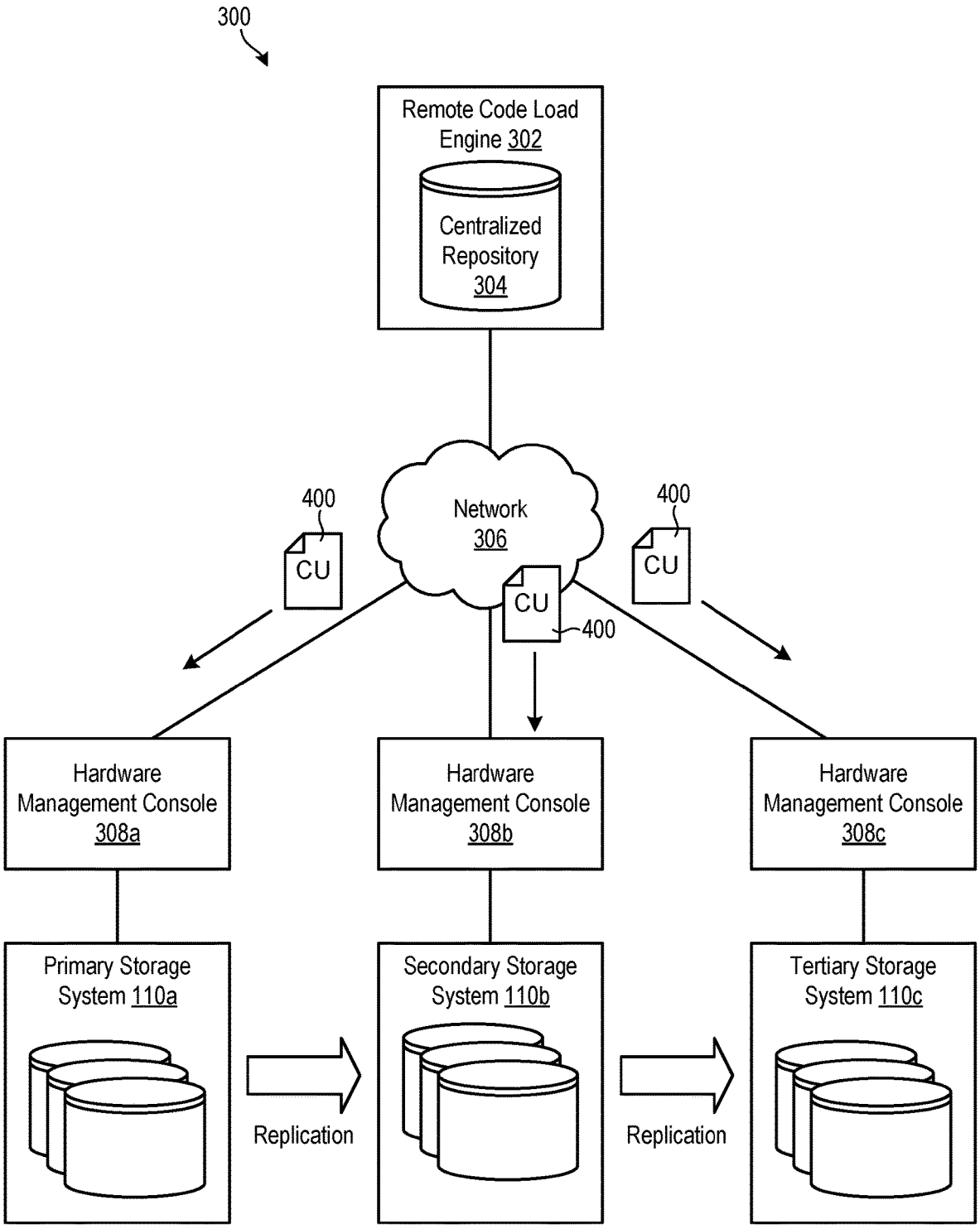

300
Remote Code Load Engine 302
Centralized Repository 304
Network 306
400
CU
400
CU
CU
400
Hardware Management Console 308a
Hardware Management Console 308b
Hardware Management Console 308c
Primary Storage System 110a
Secondary Storage System 110b
Tertiary Storage System 110c
Replication
Replication

Fig. 4

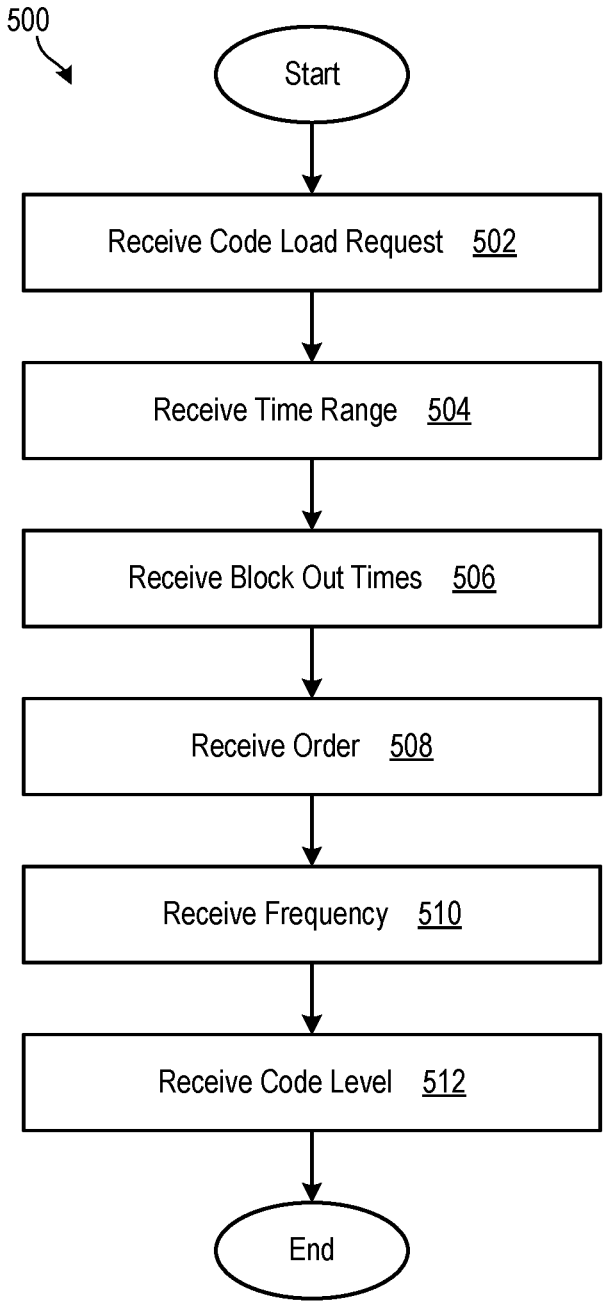

500
Start
Receive Code Load Request 502
Receive Time Range 504
Receive Block Out Times 506
Receive Order 508
Receive Frequency 510
Receive Code Level 512
End

Fig. 5

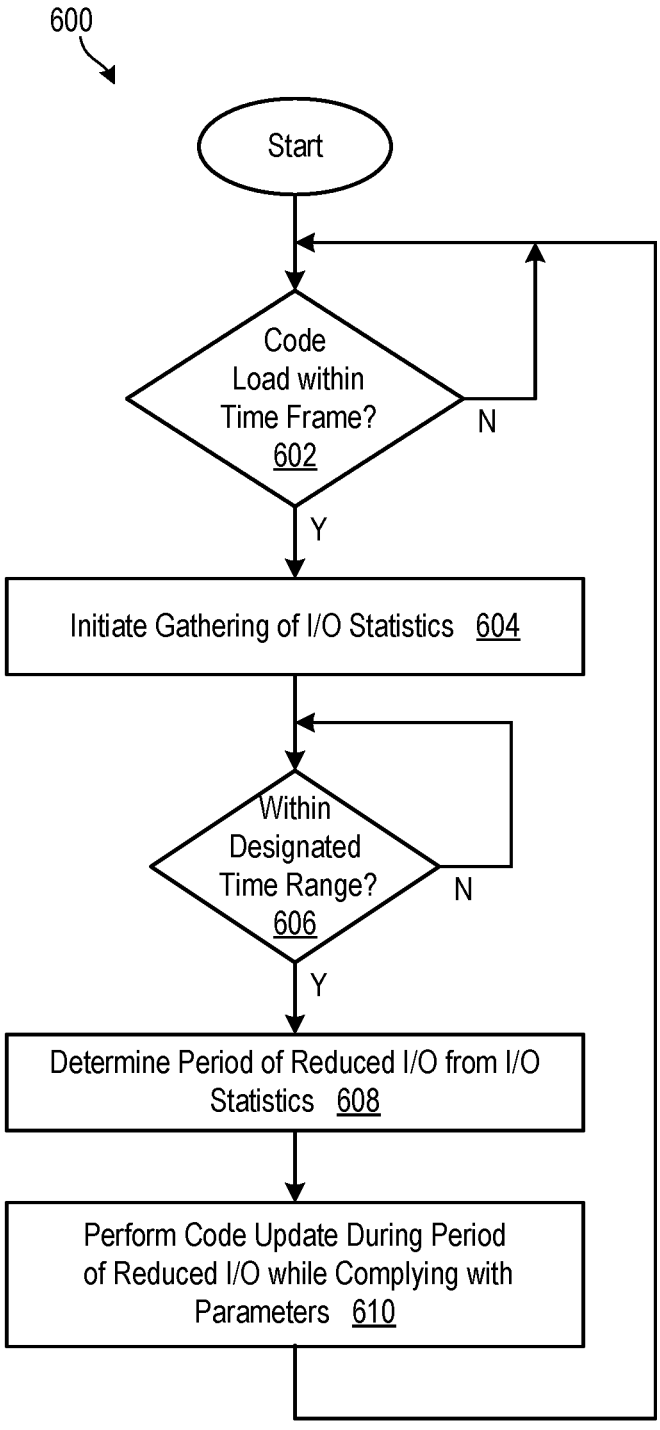

600
Start
Code Load within Time Frame? 602
N
Y
Initiate Gathering of I/O Statistics 604
Within Designated Time Range? 606
N
Y
Determine Period of Reduced I/O from I/O Statistics 608
Perform Code Update During Period of Reduced I/O while Complying with Parameters 610

Fig. 6

# INTELLIGENT AUTOMATED REMOTE CODE LOAD

## BACKGROUND

### Field of the Invention

**[0001]** This invention relates to systems and methods for updating code in enterprise storage systems.

### Background of the Invention

**[0002]** In an enterprise storage system such as the IBM DS8000™ enterprise storage system, a pair of servers may be used to access data in one or more storage drives (e.g., hard-disk drives and/or solid-state drives). During normal operation (when both servers are operational), the servers may manage I/O to different logical subsystems (LSSs) within the enterprise storage system. For example, in certain configurations, a first server may handle I/O to even LSSs, while a second server may handle I/O to odd LSSs. These servers may provide redundancy and ensure that data is always available to connected hosts. When one server fails, the other server may pick up the I/O load of the failed server to ensure that I/O is able to continue between the hosts and the storage drives. This process may be referred to as a "failover."

**[0003]** In enterprise storage systems such as the IBM DS8000™, microcode on the storage system may need to be periodically updated to ensure that the storage system is configured with the latest fixes and features. These updates are often performed concurrently, meaning that the code is updated on a storage system without disrupting its operation. Unfortunately, updating microcode on a storage system often requires an on-site technician to perform the update. This can be very expensive and time-consuming. The expense may be multiplied in situations where microcode needs to be updated on multiple related machines at multiple sites.

**[0004]** Although software exists to update code automatically, this software is often not very intelligent. For example, software-initiated code loads often do not take into account dependencies or relationships between primary, secondary, and possibly tertiary storage systems. Automated software also typically does not determine the best times to update code based on historical data access rates on the related storage systems. As a result, code loads may be performed on storage systems in non-optimal orders or at inopportune times.

**[0005]** In view of the foregoing, what are needed are systems and methods to more intelligently perform automated code loads on storage systems. Ideally, such systems and methods will take into account relationships or dependencies between storage systems. Further needed are systems and methods to automatically perform code loads at optimal times based on historical data access rates.

## SUMMARY

**[0006]** The invention has been developed in response to the present state of the art and, in particular, in response to the problems and needs in the art that have not yet been fully solved by currently available systems and methods. Accordingly, systems and methods have been developed to update code in a set of machines such as a set of storage systems. The features and advantages of the invention will become more fully apparent from the following description and appended claims, or may be learned by practice of the invention as set forth hereinafter.

**[0007]** Consistent with the foregoing, a method for updating code in a set of machines is disclosed. In one embodiment, such a method includes receiving a time range within which a code update is to be performed on a set of machines, block out times indicating when the code update cannot be performed, and an order in which the code update is to be performed on the set of machines. For some time period before the code update is performed, the method gathers I/O statistics associated with the set of machines. The method then performs the code update on the set of machines during a period of reduced I/O as determined from the I/O statistics, while complying with the received time range, block out times, and order.

**[0008]** A corresponding system and computer program product are also disclosed and claimed herein.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** In order that the advantages of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered limiting of its scope, the embodiments of the invention will be described and explained with additional specificity and detail through use of the accompanying drawings, in which:

**[0010]** FIG. **1** is a high-level block diagram showing one example of a network environment in which systems and methods in accordance with the invention may be implemented;

**[0011]** FIG. **2** is a high-level block diagram showing one example of a storage system for use in the network environment of FIG. **1**;

**[0012]** FIG. **3** is a high-level block diagram showing a system for remotely updating code in a set of storage systems;

**[0013]** FIG. **4** is a high-level block diagram showing propagation of code updates to storage systems in the set;

**[0014]** FIG. **5** is a flow diagram showing one embodiment of a method for defining a code load request; and

**[0015]** FIG. **6** is a flow diagram showing one embodiment of a method for executing a code load request.

## DETAILED DESCRIPTION

**[0016]** It will be readily understood that the components of the present invention, as generally described and illustrated in the Figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the invention, as represented in the Figures, is not intended to limit the scope of the invention, as claimed, but is merely representative of certain examples of presently contemplated embodiments in accordance with the invention. The presently described embodiments will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout.

**[0017]** The present invention may be embodied as a system, method, and/or computer program product. The computer program product may include a computer readable

storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

**[0018]** The computer readable storage medium may be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

**[0019]** Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

**[0020]** Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages.

**[0021]** The computer readable program instructions may execute entirely on a user's computer, partly on a user's computer, as a stand-alone software package, partly on a user's computer and partly on a remote computer, or entirely on a remote computer or server. In the latter scenario, a remote computer may be connected to a user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

**[0022]** Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, may be implemented by computer readable program instructions.

**[0023]** These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

**[0024]** The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus, or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

**[0025]** Referring to FIG. **1**, one example of a network environment **100** is illustrated. The network environment **100** is presented to show one example of an environment where embodiments of the invention may operate. The network environment **100** is presented only by way of example and not limitation. Indeed, the systems and methods disclosed herein may be applicable to a wide variety of different network environments in addition to the network environment **100** shown.

**[0026]** As shown, the network environment **100** includes one or more computers **102**, **106** interconnected by a network **104**. The network **104** may include, for example, a local-area-network (LAN) **104**, a wide-area-network (WAN) **104**, the Internet **104**, an intranet **104**, or the like. In certain embodiments, the computers **102**, **106** may include both client computers **102** and server computers **106** (also referred to herein as "hosts" **106** or "host systems" **106**). In general, the client computers **102** initiate communication sessions, whereas the server computers **106** wait for and respond to requests from the client computers **102**. In certain embodiments, the computers **102** and/or servers **106** may connect to one or more internal or external direct-attached

storage systems **112** (e.g., arrays of hard-disk drives, solid-state drives, tape drives, etc.). These computers **102**, **106** and direct-attached storage systems **112** may communicate using protocols such as ATA, SATA, SCSI, SAS, Fibre Channel, or the like.

**[0027]** The network environment **100** may, in certain embodiments, include a storage network **108** behind the servers **106**, such as a storage-area-network (SAN) **108** or a LAN **108** (e.g., when using network-attached storage). This network **108** may connect the servers **106** to one or more storage systems, such as arrays **110** of hard-disk drives or solid-state drives, tape libraries **114**, individual hard-disk drives **116** or solid-state drives **116**, tape drives **118**, CD-ROM libraries, or the like. To access a storage system **110**, **114**, **116**, **118**, a host system **106** may communicate over physical connections from one or more ports on the host **106** to one or more ports on the storage system **110**, **114**, **116**, **118**. A connection may be through a switch, fabric, direct connection, or the like. In certain embodiments, the servers **106** and storage systems **110**, **114**, **116**, **118** may communicate using a networking standard such as Fibre Channel (FC) or iSCSI.

**[0028]** Referring to FIG. **2**, one embodiment of a storage system **110** containing an array of storage drives **204** (e.g., hard-disk drives and/or solid-state drives) is illustrated. As shown, the storage system **110** includes a storage controller **200**, one or more switches **202**, and one or more storage drives **204** such as hard disk drives and/or solid-state drives (such as flash-memory-based drives). The storage controller **200** may enable one or more hosts **106** (e.g., open system and/or mainframe servers **106**) to access data in the one or more storage drives **204**.

**[0029]** In selected embodiments, the storage controller **200** includes one or more servers **206**. The storage controller **200** may also include host adapters **208** and device adapters **210** to connect the storage controller **200** to host devices **106** and storage drives **204**, respectively. During normal operation (when both servers **206** are operational), the servers **206** may manage I/O to different logical subsystems (LSSs) within the enterprise storage system **110**. For example, in certain configurations, a first server **206***a* may handle I/O to even LSSs, while a second server **206***b* may handle I/O to odd LSSs. These servers **206***a*, **206***b* may provide redundancy to ensure that data is always available to connected hosts **106**. Thus, when one server **206***a* fails, the other server **206***b* may pick up the I/O load of the failed server **206***a* to ensure that I/O is able to continue between the hosts **106** and the storage drives **204**. This process may be referred to as a "failover."

**[0030]** In selected embodiments, each server **206** includes one or more processors **212** and memory **214**. The memory **214** may include volatile memory (e.g., RAM) as well as non-volatile memory (e.g., ROM, EPROM, EEPROM, flash memory, local disk drives, local solid state drives etc.). The volatile and non-volatile memory may, in certain embodiments, store software modules that run on the processor(s) **212** and are used to access data in the storage drives **204**. These software modules may manage all read and write requests to logical volumes in the storage drives **204**.

**[0031]** In selected embodiments, the memory **214** includes a cache **218**, such as a DRAM cache **218**. Whenever a host **106** (e.g., an open system or mainframe server **106**) performs a read operation, the server **206** that performs the read may fetch data from the storages drives **204** and save it in its cache **218** in the event it is required again. If the data is requested again by a host **106**, the server **206** may fetch the data from the cache **218** instead of fetching it from the storage drives **204**, saving both time and resources. Similarly, when a host **106** performs a write, the server **106** that receives the write request may store the write in its cache **218**, and destage the write to the storage drives **204** at a later time. When a write is stored in cache **218**, the write may also be stored in non-volatile storage (NVS) **220** of the opposite server **206** so that the write can be recovered by the opposite server **206** in the event the first server **206** fails. In certain embodiments, the NVS **220** is implemented as battery-backed volatile memory in the opposite server **206**.

**[0032]** One example of a storage system **110** having an architecture similar to that illustrated in FIG. **2** is the IBM DS8000™ enterprise storage system. The DS8000™ is a high-performance, high-capacity storage controller providing disk and solid-state storage that is designed to support continuous operations. Nevertheless, the systems and methods disclosed herein are not limited to the IBM DS8000™ enterprise storage system **110**, but may be implemented in any comparable or analogous storage system or group of storage systems, regardless of the manufacturer, product name, or components or component names associated with the system. Any storage system that could benefit from one or more embodiments of the invention is deemed to fall within the scope of the invention. Thus, the IBM DS8000™ is presented only by way of example and is not intended to be limiting.

**[0033]** Referring to FIG. **3**, in enterprise storage systems **110** such as the IBM DS8000™, code (e.g., microcode) on the storage system **110** may need to be periodically updated to ensure that the storage system **110** is configured with the latest fixes and features. These updates may be performed concurrently, meaning that the code may be updated on the storage system **110** without disrupting its operation. In certain embodiments, this may be accomplished by routing all I/O through one server **206***a* while the other server **206***b* is being updated, and vice versa. Unfortunately, updating the code on a storage system **110** often requires an on-site technician to perform the update. This can be very expensive and time-consuming. This expense may be multiplied when there are multiple related machines **110** at multiple sites that need to be updated.

**[0034]** Although software exists to update code automatically, this software is often not very intelligent. For example, automated code loads often do not take into account dependencies or relationships between primary, secondary, and possibly tertiary storage systems **110**. Automated software also typically does not determine the best times to update code based on historical data access rates on the storage systems **110**. As a result, code loads may be performed on storage systems **110** in non-optimal orders or at inopportune times.

**[0035]** In view of the foregoing, systems and methods are needed to more intelligently update code on storage systems **110**. Ideally, such systems and methods will take into account dependencies or relationships of storage systems **110**. Further needed are systems and methods to automatically perform code loads at optimal times based on historical data access rates. One example of such systems and methods are disclosed in FIGS. **3** through **6**.

**[0036]** FIG. **3** shows one embodiment of a system **300** for remotely updating code on a set of storage systems **110***a-c*.

As shown, the storage systems **110***a-c* include a primary, secondary, and optionally tertiary storage system. These storage systems **110***a-c* may be arranged in various configuration. For example, data may be written to a primary storage system **110***a*, which may then be replicated to a secondary storage system **110***b*, and then possibly to a tertiary storage system **110***c*.

**[0037]** As shown, the system **300** may include a remote code load engine **302**, such as a cloud-based remote code load engine **302**. The remote code load engine **302** may, in certain embodiments, be operated by a service provider, such as a vendor of the storage systems **110***a-c*, to service and update storage systems **110***a-c* purchased by customers of the vendor. As shown, the remote code load engine **302** includes a centralized repository **304** that stores code updates for the storage systems **110***a-c*. In certain embodiments, these code updates **400** are transmitted to the storage systems **110***a-c* over a network **306** such as the Internet or an intranet, as shown in FIG. **4**. In certain embodiments, the code updates **400** are communicated to hardware management consoles (HMCs) **308***a-c* associated with each storage system **110**. These hardware management consoles **308***a-c* may, in turn, be used to update their respective storage systems **110***a-c* with the most recent code level.

**[0038]** Referring to FIG. **5**, in certain embodiments, a user may define a code load request and send the code load request to the remote code load engine **302**. This code load request may set forth various parameters for performing future code loads on storage systems **110***a-c* as set forth by the method **500** of FIG. **5**. For example, as shown in FIG. **5**, the remote code load engine **302** may receive **502** a code load request. The remote code load engine **302** may receive **504**, with the code load request, a time range over which the code load may be performed. This time range may include dates as well as times (e.g., June 15, 2 pm to June 18, 5 pm) when the code load may be performed.

**[0039]** The remote code load engine **302** may also, in certain embodiments, receive **506** block out times in association with the code load request. For example, a banking customer may not want code updates to occur during banking business hours, such as 9 am to 5 pm on Monday through Friday. The block out times may indicate which days, times, and/or time ranges the code load is not to be performed.

**[0040]** In certain cases, related storage systems **110***a-c* such as those illustrated in FIGS. **3** and **4** may need to be updated in a particular order. This order may be needed to avoid disruptions, avoid outages, maintain data integrity, maintain data redundancy, and/or the like. Thus, in certain embodiments, the remote code load engine **302** may receive **508**, as part of the code load request, an order in which to update code on the storage systems **110***a-c*. For example, a primary storage system **110***a* may need to be updated before a secondary storage system **110***b*, which may need to be updated before a tertiary storage system **110***c*. Each site (primary site, secondary site, tertiary site, etc.) may also have multiple storage systems **110** that need to be updated in a particular order.

**[0041]** The remote code load engine **302** may also receive **510**, as part of the code load request, a frequency with which to perform code updates on the storage systems **110** (e.g., every six months, every twelve months, etc.). Additionally, the remote code load engine **302** may also receive **512**, as part of a code load request, information regarding a code level with which to update a storage system **110** or a group of storage systems **110***a-c*. This code level may be expressed, for example, as a version or bundle number that may need to be installed on a particular storage system **110** or group of storage systems **110***a-c*.

**[0042]** Referring to FIG. **6**, one embodiment of a method **600** for processing or executing a code load request is illustrated. As shown, a remote code load engine **302** may initially determine **602** whether a current time is within a certain time frame of a code load associated with a code load request. For example, this step may determine **602** whether a code load is scheduled to occur within a certain amount of time (e.g., one month) from the current time. If so, the remote code load engine **302** may initiate **604** the gathering of input/output (I/O) statistics for the storage systems **110***a-c* on which the code load is to be performed. These I/O statistics (e.g., I/O operations per second, data access rates, etc.) may be gathered at designated intervals and stored in association with the code load request. In certain embodiments, these I/O statistics may be gathered until the code load is actually performed. Alternatively, each storage system **110** may be configured to periodically gather and save I/O statistics for up to a designated amount of time (e.g., one month) so that these statistics are available for a code load at any given point in time.

**[0043]** The remote code load engine **302** may then determine **606** whether a current time is within the time range designated in the code load request. That is, the remote code load engine **302** may determine **606** whether the current time is within the dates, times, and/or time ranges designated in the code load request to perform the code load. If so, the remote code load engine **302** may determine **608**, from the I/O statistics, a period of reduced I/O on the storage system (s) **110**. That is, the remote code load engine **302** may determine which periods, within the dates, times, and/or time ranges associated with the code load request, are associated with reduced levels of I/O on the storage system (s) **110** associated with the code load request. This may be accomplished by analyzing the I/O statistics gathered for the time period (e.g., one month) prior to executing the code load request. In general, the remote code load engine **302** may look for periods of reduced I/O (preferably the lowest I/O) in which to perform the code load on the storage system(s) **110**.

**[0044]** The remote code load engine **302** may then perform **610** the code load during the period of reduced I/O determined at step **608**. If the code load takes two hours, the remote code load engine **302** may look for a window of reduced I/O lasting two hours in which to perform the code load. In doing so, the remote code load engine **302** may comply with the parameters established in the method **500** of FIG. **5**. That is, the remote code load engine **302** may ensure that the code load is not performed during the block out times established at step **506** and that the code load is performed on the storage system(s) **110** in the order designated at step **508**. In certain embodiments, the code load may be performed on the storage system(s) **110** one at a time in the designated order. Once a code load is performed on a storage system **110**, the remote code load engine **302** may mark the storage system **110** as having its code updated and move on to a next storage system **110** in a set of storage systems **110***a-c*.

**[0045]** The flowcharts and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and com-

puter program products according to various embodiments of the present invention. In this regard, each block in the flowcharts or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. Other implementations may not require all of the disclosed steps to achieve the desired functionality. It will also be noted that each block of the block diagrams and/or flowchart illustrations, and combinations of blocks in the block diagrams and/or flowchart illustrations, may be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

**1**. A method for updating code in a set of machines, the method comprising:

receiving a code load request configured to be processed by a code load engine, the code load request having the following parameters:

a time range within which a code update is to be performed on a set of machines;

block out times indicating when the code update cannot be performed; and

a designated order in which the code update is be performed on the set of machines;

before the code update is performed, gathering I/O statistics on the set of machines; and

executing, by the code load engine, the code load request by performing the code update on the set of machines during a period of time determined from the I/O statistics, while complying with the time range, block out times, and designated order.

**2**. The method of claim **1**, wherein the set of machines is a set of storage systems.

**3**. The method of claim **2**, wherein the set of storage systems comprises primary, secondary, and optionally tertiary storage systems.

**4**. The method of claim **1**, further comprising initiating the code update from a location that is remote from the set of machines.

**5**. The method of claim **4**, further comprising receiving, at the location, the time range, block out times, and designated order.

**6**. The method of claim **1**, wherein performing the code update comprises performing the code update without disrupting operation of the set of machines.

**7**. The method of claim **1**, wherein the period of time corresponds to an amount of time needed to perform the code load time range.

**8**. A computer program product for updating code in a set of machines, the computer program product comprising a computer-readable storage medium having computer-usable program code embodied therein, the computer-usable program code configured to perform the following when executed by at least one processor:

receive a code load request configured to be processed by a code load engine, the code load request having the following parameters:

a time range within which a code update is to be performed on a set of machines;

block out times indicating when the code update cannot be performed; and

a designated order in which the code update is be performed on the set of machines;

before the code update is performed, gather I/O statistics on the set of machines; and

execute, on the code load engine, the code load request by performing the code update on the set of machines during a period of time determined from the I/O statistics, while complying with the time range, block out times, and designated order.

**9**. The computer program product of claim **8**, wherein the set of machines is a set of storage systems.

**10**. The computer program product of claim **9**, wherein the set of storage systems comprises primary, secondary, and optionally tertiary storage systems.

**11**. The computer program product of claim **8**, wherein the computer-usable program code is further configured to initiate the code update from a location that is remote from the set of machines.

**12**. The computer program product of claim **11**, wherein the computer-usable program code is further configured to receive, at the location, the time range, block out times, and designated order.

**13**. The computer program product of claim **8**, wherein performing the code update comprises performing the code update without disrupting operation of the set of machines.

**14**. The computer program product of claim **8**, wherein the period of time corresponds to an amount of time needed to perform the code load.

**15**. A system for updating code in a set of machines, the system comprising:

at least one processor;

at least one memory device operably coupled to the at least one processor and storing instructions for execution on the at least one processor, the instructions causing the at least one processor to:

receive a code load request configured to be processed by a code load engine, the code load request having the following parameters:

a time range within which a code update is to be performed on a set of machines;

block out times indicating when the code update cannot be performed; and

a designated order in which the code update is be performed on the set of machines;

before the code update is performed, gather I/O statistics on the set of machines; and

execute, on the code load engine, the code load request by performing the code update on the set of machines during a period of time determined from the I/O statistics, while complying with the time range, block out times, and order.

**16**. The system of claim **15**, wherein the set of machines is a set of storage systems.

**17**. The system of claim **16**, wherein the set of storage systems comprises primary, secondary, and optionally tertiary storage systems.

**18**. The system of claim **15**, wherein the instructions further cause the at least one processor to initiate the code update from a location that is remote from the set of machines.

**19**. The system of claim **18**, wherein the instructions further cause the at least one processor to receive, at the location, the time range, block out times, and designated order.

**20**. The system of claim **15**, wherein performing the code update comprises performing the code update without disrupting operation of the set of machines.

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